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Columbite-tantalite and associated minerals in the placers of Lemmenjoki area, northern Finland

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Placer columbite-tantalite grains were studied from tributaries of the Lemmenjoki river in the Paleoproterozoic granulite belt of northern Finland. The grains were found in the glaciofluvial river gravels, sands and terraces of the Miessijoki and Puskuoja rivers. The glacial transport has been in the direction of SW-NE trending river valleys that cut the general strike of the strongly strained metasedimentary granulites and magmatic mafic-ultramafic rocks.The columbite-tantalite grains occur with native gold lead and bismuth, more than 40 platinum group mineral (PGM) phases, thorianite-uraninite, wolframite, scheelite, cassiterite, and tapiolite-(Fe) as inclusions in columbite-tantalite grains or as homogenous separate grains. Occasionally, tapiolite crystal are replaced by microlite and plumbomicrolite along fractures. Tapiolite and columbite-tantalite sometimes contain inclusions of strüverite. Other heavy minerals in the placers include magnetite, ilmenite, rutile, hematite, chromite, limonite and vanadinite. The columbite grains analyzed plot in the field of ferrocolumbite whereas tantalite occurs in about equal amounts as ferro- and manganotantalite. Tapiolite has < 2.8 wt.% MnO and < 6.2 wt.% TiO_2 The TiO_2 content in the columbite–tantalite and tapiolite is exceptionally high in the electron microprobe analyses. Thus, about 35 % of the common lattice cites of Ta and Nb may be replaced by Ti. In addition, columbite-tantalite may locally have notable Sc (up to 2 wt.% Sc_2O_3), W, Zr, Hf and the heavy rare-earth elements. Manganocolumbite is not found at all in the Lemmenjoki area. In the Lemmenjoki microlite, Ta has been partly replaced by Nb and Ti, and Na and Ca by varying amounts of Pb, U, Th, Fe, Mn, Sn, and Ce. Because of the high U and Th content the mineral is partly metamict and altered to a hydrous variety. Especially the amount of Pb in the analyzed grains is exceptionally high, and the mineral grade to plumbomicrolite. The Lemmenjoki wolframite contains usually 1-2 wt.% MnO, corresponding to 6-9 mol. % of the hübnerite end member.The wolframite crystal plates macroscopically resemble columbite-tantalite, but the grain plates are not grooved. Thorianite and uraninite form a solid solution series that contains also varying amount of lead. The grain analyzed from Puskuoja River is expeptionally U- and Pb-rich having an empirical formula of $(Th_{0.55}U_{0.35}Pb_{0.19})O_2$. Uraninite-thorianite is steel gray or brownish black in color with a metallic lustre. The columbite-tantalite grains analyzed reveal a trend from Fe-rich to Mn-rich compositions and progressive enrichment of Ta over Nb. Similar composition trends have been found in many beryl-coumbite and beryl-columbite–phosphate pegmatites. Crystallization start from ferrocolumbite, and it is followed by manganotantalite and possibly other Ta-rich minerals. Ferrocolumbite often crystallizes in the border parts of the pegmatites, manganocolumbite and manganotantalite in the central parts of the pegmatite. The Nb-Ta-minerals in Lemmenjoki area are exceptionally rich in Ti. The source of the Nb-Ta bearing pebmatites may be the granulitic rocks because they also are highly enriched in Ti having local abundant rutile.